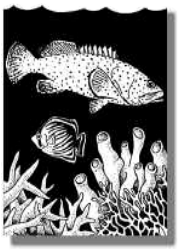

Reef fish spawning aggregation monitoring in Pohnpei, Federated States of Micronesia, in response to local management needs

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Introduction

The global disappearance of tropical reef fish spawning aggregations (FSAs) and the associated decline in fish populations from aggregation overfishing is now widely recognized (Sadovy 1995; Coleman et al. 2000; Domeier et al. 2002). Along with this recognition is an acknowledgement that FSAs need immediate management attention, even in lieu of baseline data (Johannes 1997, 1998). To manage FSAs, several traditional (Western) and customary (e.g. customary marine tenure) management options are available that alone or in combination can be used to prevent FSA overfishing. Among these options are size restrictions, catch quotas, bag limits, marine protected areas (MPAs) and species-specific catch bans, each operating on a permanent or temporary (spawning season-specific) basis. However, in many locales, the number of options is actually few owing to the limited understanding of species' life histories and FSA dynamics, and a basic lack of resources for monitoring and enforcement activities over long coastlines. In addition, those few remaining options may require unconventional approaches to implementation based on local — not regional — circumstances, perhaps even on an FSA-by-FSA basis.

Within the Indo-Pacific, management measures specific to FSAs have been enacted in several island nations, including the Federated States of Micronesia (FSM) (Pohnpei, one of the FSM's four states), Palau, Indonesia (Komodo), Solomon Islands (Munda), and Papua New Guinea (Manus) (Johannes et al. 1999; Rhodes and Sadovy 2002a; Pet et al. in press; R. Hamilton pers. comm. 15 April 2005). None, however, has yet provided complete and permanent protection for all FSAs within their respective jurisdictions, such that FSA management actions may be considered as incomplete or temporary.[4] In Manus and New Ireland Provinces (Papua New Guinea), six local communities that exploit FSA located within their uncontested customary fishing grounds have imposed a combination of gear restrictions, harvesting restrictions and temporary closures at five FSAs, but with a view to stock recovery and future sustainable harvest. In Komodo National Park, FSA protection is provided through gear restrictions and the incorporation of known spawning sites in no-take zones, although full implementation of the provisions has yet to take place (for more information, see www.komodonationalpark.org). In FSM and Palau, partial area and seasonal FSA protection is provided through MPAs (as permanent no-take zones) around some, but not all, known spawning sites. Market-based sales bans are in place during portions of the target species' reproductive seasons in both locales. Palau has also enacted an export ban.

In Pohnpei, FSM, while MPAs appear to have reduced aggregation fishing at one spawning site (some poaching still occurs), migratory pathways are left open to fishing and there is now preliminary evidence to suggest that fishing along these pathways may offset other area-based management measures (Rhodes et al. unpublished data). In addition, substantial numbers of reproductively active individuals appear in markets outside the sales ban period.[5] Finally, subsistence fishing is left unregulated in local FSA legislation, except in MPAs. However, the removal of reproductively active fish for subsistence use may equal or exceed that of commercial catch, including during the sales ban period. Therefore, the need for management improvements for FSA-forming species is clear, as is an investigation of the effects of subsistence fishing on FSAs.

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4. Complete and permanent protection refers to the protection from fishing of all reproductively active fish within or en route to an FSA site, including along migratory pathways and at "staging" areas used by individuals between or prior to moving to FSA sites. Permanent protection refers to protection during a species' entire spawning season. Complete and permanent protection is globally accepted among scientists, managers and conservationists as the best method to protect FSA from loss and one of the key protective measures for maintaining fish populations. This form of management is viewed as necessary because partial protections have consistently been shown to fail, and all but the lightest levels of fishing are known to result in the loss or decline of FSAs. The inability of resource managers to devise measures that would allow certain levels of fishing is limited by an incomplete understanding of: 1) aggregation dynamics, 2) the widely varying responses of individual species and FSAs to fishing, and 3) our lack of understanding of which and how many local FSAs are needed to maintain populations.
5. The sales ban was instituted in 1992 as part of the Pohnpei State Marine Protection Act of 1992.

In Pohnpei, a scientific investigation of an FSA-forming species was conducted at a locally recognized (and fished) FSA between 1998 and 1999 (Rhodes and Sadovy 2002a, 2002b; Rhodes et al. 2003). Study findings and subsequent discussions generated greater awareness of FSA vulnerability and created an interest among local organizations to improve FSA management. In recognition of this interest and in light of the need to improve FSA protection, The Nature Conservancy (TNC) trained key stakeholder organizations (Conservation Society of Pohnpei (CSP), Pohnpei Division of Marine Resource Development (DMRD), Pohnpei Environmental Protection Agency, College of Micronesia and Pohnpei Agricultural and Trade School (PATS)) in FSA monitoring techniques in 2001 to facilitate monitoring of key FSA sites and species.

Here we present monitoring results on abundance and reproductive season for three FSA-forming species over four years (2001–2004), describe the results in relation to FSA dynamics and highlight the usefulness of the data for improved management in Pohnpei.

Methods

Beginning in 2001 (Month E, see below), CSP and DMRD initiated monitoring at a locally protected FSA site to determine the reproductive seasons and potential inter-annual changes in lengths and abundance of spawning fish of three locally important species. Monitoring was conducted monthly during both full and new moon periods for the first 12 months and during full moon periods only thereafter. Monitoring activities during 2003 through 2004 focused only on full moon periods between Months C and G, inclusive, which were determined to mark the beginning and end of the spawning seasons for these species at that site. Various attributes of the FSA were observed and measured to inform future management decisions and to gain insight into the response of the three species to the newly formed FSA-based MPA[6] and the commercial sales ban. Specifically, the determination of the species-specific spawning seasons was necessary to make needed changes to the current commercial management (sales ban) currently in place.

Monitoring was conducted by a three-member team, each with a specific task (e.g. abundance counts, length-frequency estimation, and observation of behaviour). Following initial training during the 2001 monitoring workshop, skills re-training was conducted annually prior to each monitoring season and monthly within seasons for length estimation. Monitoring was conducted monthly over a three-day period just prior to a full or new moon, and was consistent in relation to the lunar day and time of day. Monitoring was conducted along four non-overlapping transects 100 m in length and 15 to 20 m in width, at a depth of either 13 or 30 m (depending on the species, area and depth of the aggregation), as specified in a subsampling protocol instituted during the 2001 training workshop. Aggregations were adjacent to each other within the site, with clearly defined boundaries. Final estimates of abundance were calculated by extrapolating transect counts to total counts based on the size of the transect areas relative to the total FSA area.

In discussing findings, we refer to the three species as "Species A", "B" and "C" rather than using the actual species name because of the continued threat of commercial fishing activity in Pohnpei and the broader region. Similarly, we have coded the actual months of the reproductive season and use relative abundance (using an arbitrary 100-point scale) instead of actual abundance. Coded months are in the same order as the calendar year but are shifted (i.e. Month A is not January). Results from the length frequency and behavioural components of the monitoring are not presented here.

Results

Monitoring results from the 2001–2004 period provide a clear picture of the spawning season for the target species at the monitoring site for management decision-making (Fig. 1). Figure 1 depicts both the general seasonal consistency in which FSAs form and the inherent variability in inter-annual FSA formation and monthly abundance.

Species A was found to aggregate during four lunar months of the year, with highest abundance within a three-month period that initiated in Month D or E. The month of peak abundance varied among years. Similarly, Species B formed annual aggregations either in Months E and F or in Months D and E, with peak abundance typically during the initial spawning month. Species C demonstrated a four-month spawning period beginning in either Month C or D. Minor aggregations occasionally formed one month earlier (e.g. 2003, 2004), such that the duration of the spawning season could be considered five months. Preliminary evidence from a 2005 tagging study suggests the aggregation may be composed primarily or exclusively of males during the initial month of the season (i.e. Month C in 2004) (Rhodes et al. unpublished data). As with Species A and B, the initial month of FSA formation and month of peak abundance for Species C varied among calendar years.

6. The FSA-based MPA initiated in 1995 was expanded in 1999 to incorporate three aggregation sites, compared with only one that fell within the MPA boundaries when it was initially established.

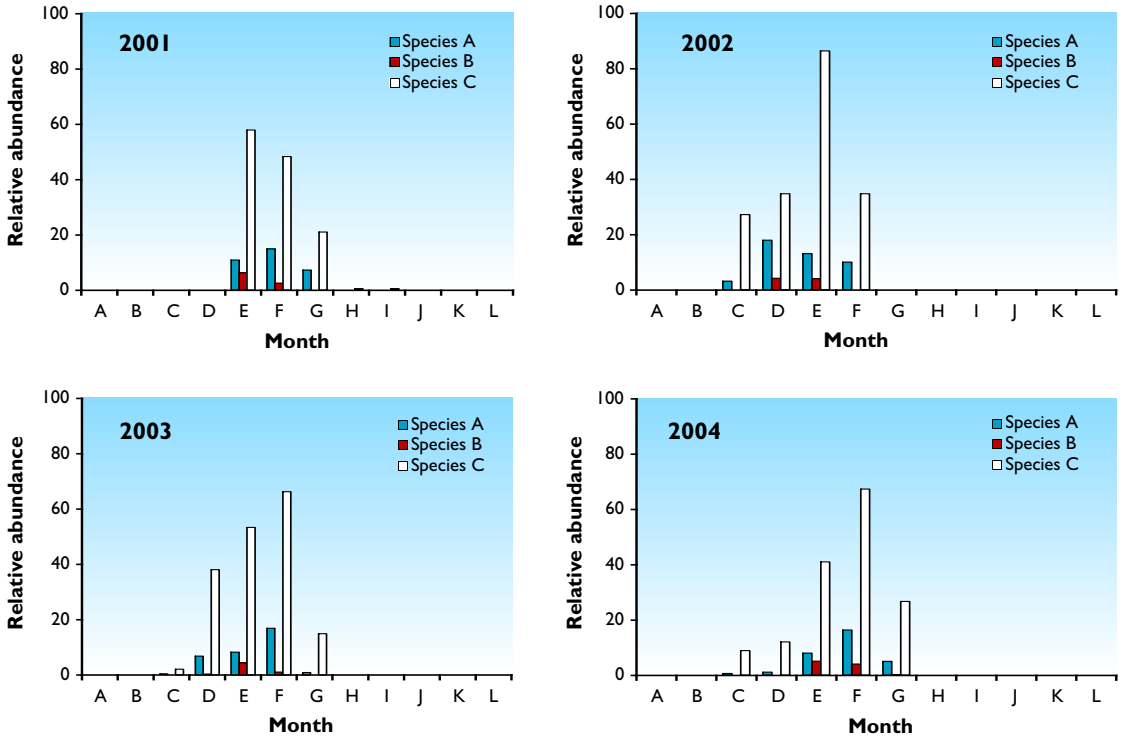

Figure 1. Monitoring results (relative abundance) of Species A, B and C (2001–2004). Monitoring was conducted for 27 consecutive months beginning in Month E, 2001. Monitoring in 2004 was conducted only between Months C and G, inclusive.

Discussion

General background

Pohnpei, Federated States of Micronesia, consists of 607 islands within four major island groups (one of which is the main island group of Pohnpei, Ant Atoll and Pakin Atoll) and 6117 km of coastline. Within these areas, marine resource monitoring and enforcement is administered through the Pohnpei Division of Marine Conservation (DMC) under the Department of Lands and Natural Resources, and by the Pohnpei Division of Marine Resource Development (DMRD) under the Department of Economic Affairs. These two divisions have a combined total of 18 employees, including nine conservation officers, and an annual operating budget of less than 140,000 United States dollars, including salaries. The DMRD/DMC is based within the main island group and located in the population and transportation centre, Kolonia, which contains the central market facility for the sale of coastal marine resources to about 35,000 inhabitants. In addition to the central market facilities, several additional seafood markets are dispersed around the island of Pohnpei, the most distant one about 35 km from the town centre. All exports and sales of FSA-derived products occur in Kolonia.

Current management and impacts to FSA

Currently, Pohnpei has two management measures specific to protecting spawning fish: 1) a two-month sales and possession ban for all fish markets, restaurants, and other points of sale, and 2) an MPA protecting the largest locally recognized FSA site for three locally important species. The sales and possession ban was originally enacted to protect an entire family of fish during what was perceived to be the main spawning period, even though many members of the family do not aggregate to spawn or spawn partially or exclusively outside the ban periods. At the time the ban was enacted, no detailed information on spawning season was available for any species within the family. Even now, the reproduction seasons and spawning patterns for several species covered by the ban are unknown. Therefore, the blanket sales and possession ban may not protect certain species within the family, since it does not cover their respective spawning times.

Substantial numbers of reproductively active fish appear in markets during months not currently covered by the sales ban. There is also some evidence of illegal sales of FSA-forming species during the sales ban period. The allowance of subsistence fishing during the sales

ban period also provides the potential for overfishing since any number of fish can be taken by any number of fishers throughout the spawning season. Other known FSAs for these species are also actively fished throughout the spawning season, although the actual volume and impact of this fishing are unknown.

While the MPA provides nearly complete protection for spawners at the FSA site (some poaching occurs), key migratory pathways are left open to fishing. There is now growing evidence that both Species B and C utilize specific pathways to reach FSA sites and may concentrate in "staging" areas between spawning months (Colin et al. 2003; Rhodes et al., unpublished data; M.H. Tupper, Palau International Coral Reef Center, pers. comm. 15 June 2005). In Pohnpei at least, fish from the MPA-protected FSA are being actively and sometimes heavily fished along migratory pathways and at other unprotected FSA sites. Therefore, some form of management that protects reproductively active fish throughout the spawning season, including at all migratory pathways and FSA sites, is necessary.

Potential for changes in FSA management in Pohnpei

Area-based options

Although area-based management options (i.e. MPAs), when properly placed around staging and spawning areas, have great potential to permanently protect FSAs (but, see Hviding 1998; Foale and Manele 2004), their potential as a catch-all management tool in Pohnpei appears limited. This limitation owes to the wide geographic range of FSAs in the state (even in the main island group), the scarcity of surveillance resources needed to enforce them and the large areas required to adequately protect all FSAs and migratory pathways, even those around the main island group. For example, the currently monitored FSAs, if protected by an area ban enclosing both catchment and spawning areas, would encompass about 20 km^2, or one sixth of Pohnpei's barrier reef (Rhodes et al. unpublished data). Since there is more than one FSA within the main island group, the use of MPAs to protect the fish utilizing them would place a considerable amount of reef off-limits to fishing — a difficult proposition for politicians in terms of garnering support from the local community and fellow legislators. Moreover, the funding necessary to enforce these areas is greater than what is available (see *General background* section), particularly when other DMRD and DMC activities are factored in. Therefore, while it may be feasible to protect one or two of the larger, more abundant or biodiverse FSAs, the wide-scale use of MPAs in Pohnpei as a management tool is currently impractical from an economic perspective.

Market-based options

Based on the 2001–2004 monitoring findings, Pohnpei now has sufficient details on spawning seasonality to make changes to the current commercial sales ban. Based on the seasonal data presented above, Pohnpei can opt to enact: 1) species-specific commercial bans during each species' respective spawning season; 2) a blanket commercial ban that includes all three species and encompasses the longest of the three species' spawning seasons (and considers the inherent variability in spawning seasons); or 3) a commercial ban that focuses on common peak months in either a species-specific manner or as a blanket type ban. In the latter instance, a commercial ban could be in place during Months D to G, inclusive.

Here, we use the term "commercial ban" to mean combined sales, catch, export and possession bans, since sales bans alone have proven insufficient to fully protect reproductively active fish during the spawning season in Pohnpei; this is demonstrated by the substantial number of gravid fish available in markets during periods when the sales ban is not in effect, the capture of individuals from other FSA sites, and heavy fishing often observed to occur in staging areas for commercial and subsistence use during and outside sales ban periods. If properly enacted and enforced, the proposed measures have the potential, based on local circumstances, to effectively stop all or most FSA fishing within Pohnpei (including nearby atolls) for these three species, since catch and possession, along with sales, would be prohibited. For subsistence purposes, a bag limit could be established (e.g. five fish per person, 10 fish per boat), although the ability to effectively enforce such a limit would be constrained by some of the same conditions listed above, especially resource limitations for surveillance. A more meaningful and effective method to eliminate all FSA fishing or catch of reproductively active fish within reproductive periods would be to also ban subsistence fishing for these species.

Species-specific, market-based management provides an alternative to resource-intensive, area-based management schemes that, for Pohnpei, have been only partially successful in eliminating fishing pressure on FSAs to date. Such bans could be broadened to include other species once their spawning seasons are identified. Additionally, area protection can be effective in Pohnpei, but only when combined with commercial bans. Area protection could be used more effectively by targeting only key FSA sites (i.e. sites of high abundance and/or biodiversity), which would also reduce

funding requirements for the state and improve the potential for effective monitoring and enforcement.

While we acknowledge that these proposed measures may not work in all regions of the Indo-Pacific, a number of countries have circumstances similar to Pohnpei (e.g. large management areas, limited management resources and centralized markets). These countries may consider a similar approach that relies on a mix of management tools tailored to local political and economic reality; that is, combined area and temporal sales, catch, export and possession bans. Similar management measures are in place in Palau, which has included at least three FSAs under area protection in combination with a sales and export ban during much of the spawning season. Adjustments to that program to match sales bans to spawning times could also improve management there.

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